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Abstract

In this paper we describe a novel metaphor for developing interactive computer applications, *the constrained ink metaphor*. Crucial to the development of the constrained ink was an aim to find simple and natural means for defining and implementing interaction among persons. We will describe how we was lead to considering this metaphor, some basic inks following the metaphor, and finally some typical applications and their impact on the development of the metaphor.

1 Background, Goals and Influences

1.1 The interLiving Project

The interLiving project aims to study and develop, together with families, technologies that facilitate generations of family members living together with the objectives: to understand the needs of diverse families; to develop innovative artefacts that support the needs of co-located and distributed families; to understand the impact such technologies can have on families (Beaudouin-Lafon, 2002, Hutchinson, 2003).

1.2 Goals and Research Questions

A key objective of the interLiving project is to experiment with different design methodologies. We would like to develop better ways of letting the family members directly influence and shape the design of communication technologies we develop together with them.
The *premiere goal* with the particular work described in this paper is: to develop an infrastructure and metaphor that will enable us to build applications were we leave as much us possible open to the co-development with families, even late in the development process. *Secondary goals* are: i) that it should be easy and natural to develop all our intended applications by means of this infrastructure and metaphor; ii) that the metaphor should encourage development of applications that are fun to use (and develop!)
Research Questions are:

- Is it possible to create an infrastructure and metaphor of the type we strive for in the goals?
- For which types of applications is the metaphor well suited and for which types is it not naturally applicable?

1.3 Technology Probes

As inspiration and triggering techniques we have used technology probes. A ‘technology probe’ combines the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field-testing the technology and the design goal of inspiring users (and designers) to think of new kinds of technology (Beaudouin-Lafon, 2002 Chapter 2). The

probe that influenced the development of the applications we currently are working on most is *The Message Probe*, a simple application that enables members of a distributed family to communicate with digital notes using a pen and tablet interface. Already at early stages of the development of applications inspired by these probes we realized that we required something that both was fun to use and easily adoptable to various and changing requirements. This in turn led us to the development of *The Constrained Ink Metaphor*.

1.4 Influencing Approaches

There are of course a lot of achievements in the history that has inspired, or at least influenced, our development. For instance Ivan Sutherlands pioneering work on Sketchpad (Sutherland, 1963), the NLS system in the SRI project (Engelbart, 1975), the very direct manipulated A Reality Toolkit (ARK) (Smith, 1987), editors for drawing and animation like Macro Mind Director, Calendaring facilities (Beaudouin-Lafon, 2002), and the more recent KidPad (Benford, 2000). We have also been inspired by work done in CSCW and design patterns (Eiderbäck 2001).

2 Ink of Various Kind and their Usage

2.1 The Metaphor: What, Why, and How

The constrained ink metaphor is a novel metaphor for developing interactive computer applications. The idea of it sprung from an attempt to develop a common base for a message central and a distributed shared drawing editor, intended for communication between family members possible living in different households. In the former case we focus on the same place different time aspects were we want to provide for submitting shared notes visible within certain time frames. In the latter case we focus on same time different place aspects were we for instance want to provide for co-operative drawing, communication and address awareness aspects. Our intention is to enabling communication of both important facts and more informal chatting in a way youngsters, adults, and elder members of the family, computer literate or not, could find useful and "fun"! We discussed the concept together with the families and agreed that it seemed to be promising, useful and fun.

2.2 Ink

Central to the Constrained Ink Metaphor, as its name suggests, is the Ink!

2.2.1 Natural Inks

There are a lot of different types of ink that could be considered natural in the sense that they more or less have their counterparts in the real world. For instance, we have the invisible ink that even a small children most likely have experiences from using a special purposes pen with ink that only appears after one heat the paper it is written on. Another natural ink is the aging ink; actually this is the way all inks work, where the ink slowly disappears from the material it is written on. However in our computerized versions we have speeded up and made the aging more controllable.

The Coloured Ink

As a basis we use ordinary coloured ink, i.e. all inks have a defined colour or texture. On top of this basic ink all the other inks was developed, by applying various constraining schemas that made them behave and response to external events.

The Invisible Ink

The Invisible Ink is the most natural of all the constrained inks.

Context
The user wants to write a note that should be presented at a specified time in the future. Thereafter the note should stay until someone actively removes it.

Problem
How could we provide model providing a means to construct entities that should appear at a specific time in the future? How could we develop a model that fits into and is suitable for all the various applications we are developing within the project?

Forces
The model should be natural to use. The usage of the model should not constrain the process or the interaction. The model should be natural for handling constrained entities of various kinds as graphical one, e.g. lines and ovals, and non graphical ones, e.g. email and speech. It must be feasible to implement the model in software.

Solution
Make a computerized version of an invisible ink. For convenience for programmers incorporate the ink model into the system's ordinary model of drawing with various colours and textures, i.e. it should be possible to use the ink for colouring objects even in "non-ink aware" applications. Therefore separate parts for handling the interaction with the ink from ones handling its behaviour and ones handling its visible appearance. In this way one could easily change or adopt new behaviour to ink and at a very fined grained level control its constraints.

The Aging Ink

The Aging Ink is ink that disappears after a pre-defined time. It works as ordinary ink, but we have speeded up the decaying process and also made it more abrupt.

Context
The user wants to write a note that is valid from the time the note is written until a certain time in the future.

Problem and Forces
The problem forces are the same as for the Invisible Ink but now the entities should disappear after a while instead.

Solution
The solution follows the same lines as the one for the Invisible Ink. With the separation of controlling and behaviour from appearance we only has to replace the constraint controller for one that makes the ink disappear after a certain time, instead of appear as for the former ink.

2.2.2 Generally Constrained Inks

After discussing applications, and reflecting on our earlier prototypes among ourselves but also with our families we considered the ink metaphor in more dept. We realised that the natural inks would not solve all the problems that we intended. We require to entities responding to general events, as someone pushing a button or joining a family's network. Therefore we decided to expand the metaphor further to see if it could be useful even in ways that not have their direct counterparts in ink from the natural world.

2.2.3 Asymmetric Inks

We also want to be able to show things differently, or at different times, at diverse platforms. Sometimes everything should be visible to all users in the same way at other times some parts are

not visible to all users or just presented differently to some of them. Entities could even be handled on dissimilar platforms and by different media by various users, i.e. on use speech at a PDA whereas another user has a graphical platform with a text interface. Therefore we try to investigate the impacts these situations has on the ink and try to develop ink that also are suitable for them.

2.2.4 Inks Intended for Sharing

In some senses we could use the previously described inks for sharing. We have inks visible at all platforms, inks that appear differently for diverse users, etc. However, only relying on these inks makes sharing of artefacts required in a more general sense very clumsy. To address this we have played with inks that could define certain (filled) areas where all other inks painted on the area should be visible by a shared and connected community. Thereby we could easily, within the limits of the constrained ink metaphor, even provide for shared desktops and other means of co-operative work. Therefore we also investigate how this type of ink is usable and fits into the metaphor.

3 Some Typical (Ink Based) Applications

3.1 Type of Application

The applications we currently are working on affect the type of ink required in different ways. In this section we very briefly exemplify of the various types of applications we consider. These considerations are a basis for our further development and exploration of the constrained ink metaphor. Some typical kinds of applications are:

- *Synchronous vs. Non-Synchronous Applications.* There is an obvious difference between synchronous and non-synchronous applications. In the former case communication takes effect momentarily whereas the latter case is more indirect, probably taken its way via some server, storage medium, or alike.
- *Shared vs. Non-Shared Applications*. Another situation we must consider is if the application should be shared, i.e. everyone manipulates a shared set of entities, or non-shared where different users could manipulate their own restrictive set of the entities.
- *(Just) Graphical vs. Multimedia*. Typical shared applications of today also provide for other media than graphics. Examples are telephony over IP, and videoconferences.
- *Sinking Ships*. An archetypical application where different users at certain times sees different parts of the entities or even presented in different ways is the famous game Sinking Ships.

3.2 Applications

Currently we are focusing on two different applications. The InkPad and the Door. We also explore some types of interaction, not central in the other two, in a Pie Diagram framework. In the sense of exploring the constrained ink metaphor the InkPad is the most central and new kinds of ink and constraints are first tested within this application.

3.2.1 A Shared (Drawing) Editor, InkPad

The InkPad is a tool with the main aim to enabling free and non-formal communication among family members of all ages. To support free communication we try to make InkPad an as relaxed environment as possible. The focus on this prototype is on enabling communication of both

important facts and more informal chatting in a way both youngsters, adults, and elder members of the family, computer literate or not, could find useful and "fun".
The user could choose ink from any of the previously described types of ink. In this way the user could achieve effects as writing messages and notes that will appear or disappear at specific times. We have also considered other media, such as audio, video, and speech.

3.2.2 Message Central, the Door

We also develop a message central nick named *The Door*, from the first intended placement in the household. The Door prototype is an effort to improve the communication and scheduling of activities among family members. At the start we concentrate on communication between members living in the same household. In this case we use the ink metaphor for controlling and delivering messages.

3.2.3 Pie Diagrams

Pie Diagrams are just like ordinary pop up menus but circular. In particular we investigate how invisible ink could be used to supporting expert users that now the relative location of certain submenus and the items they want to chose. The ink is constrained to only paint a certain sub-pie if the user "fires a certain event", by for instance stopping the movement more than a pre-defined time limit. In such a case the ink reacts by switching from transparent colour to non-transparent ones and thereby makes the pie visible.

4 Conclusions and Future Work

In this paper we have described the *Constrained Ink Metaphor* by describing various forms of (constrained) inks and their usage. We demonstrated that the metaphor is both natural and useful for developing a various set of interactive and distributed applications.
From now on we will investigate the metaphor further by using it to full extent while continuing the development of a various set of applications within the interLiving project.

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